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Aging and Fluency Based Illusions in Recognition Memory

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Abstract

We examined age related differences in susceptibility to fluency-based memory illusions. The results from two experiments, using two different methods to enhance the fluency of recognition test items, revealed that older and younger adults did not differ significantly in terms of their overall susceptibility to this type of memory illusion. Older and younger adults were also similar in that perceptual fluency did not influence recognition memory responses when there was a mismatch in the sensory modality of the study and test phases. Likewise, a more conceptual fluency manipulation influenced recognition memory responses in both older and younger adults regardless of the match in modality. Overall, the results indicate that older adults may not be more vulnerable than younger adults to fluency-based illusions of recognition memory. Moreover, younger and older adults appear to be comparable in their sensitivity to factors that modulate the influence of fluency on recognition decisions.

Keywords

Age differences; recognition memory; false memory; illusions; fluency

The past decade has seen substantial interest in research investigating the effects of aging on memory intrusions and distortions. Much of this research has used the Deese-Roediger-McDermott (DRM) and the post-event misinformation paradigms to elicit false memories, and the results indicate that older adults are more susceptible to these types of memory distortions than are younger adults (for reviews, see Balota, Dolan, & Duchek, 2000; Jacoby & Rhodes, 2006; Roediger & McDaniel, 2007). In this paper, we investigate age differences in false memories resulting from experimental manipulations that influence the way that stimuli are processed during the retrieval phase; specifically, manipulations that influence the processing fluency of recognition test words, and the interpretation that participants adopt for enhanced fluency of test words.

The *fluency heuristic* is the term used to describe the finding that items that are processed quickly and easily are experienced differently than items that are less fluently processed. A growing body of research indicates that fluent processing can be unconsciously attributed to familiarity (Jacoby & Whitehouse, 1989; Whittlesea, Jacoby, & Girard, 1990), aesthetic preferences (Bornstein, 1989; Kunst-Wilson & Zajonc, 1980; Mandler, Nakamura, & Van

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Zandt, 1987; Whittlesea & Price, 2001; Zajonc, 1980), perceptual clarity (Goldinger, Kleider, & Shelley, 1999; Masson & Caldwell, 1998; Whittlesea, Jacoby, & Girard, 1990), duration (Witherspoon & Allan, 1985), loudness (Jacoby, Allan, Collins, & Larwill, 1988), task difficulty (Jacoby & Kelley, 1987), fame (Jacoby, Woloshyn, & Kelley, 1989), or validity (Boehm, 1994; Begg, Robertson, Grappuso, Anas, & Needham, 1996; Hasher, Goldstein, & Toppino, 1977), depending on the context and circumstances. In the context of a recognition memory task, items that are fluently processed are more likely to be judged as “old.” Although the subjective experience of fluency is a valid cue for remembering (Jacoby & Dallas, 1981; Johnston, Dark, & Jacoby, 1985; Murrell & Morton, 1974; Neisser, 1954), it can also lead to memory illusions when processing fluency is experimentally enhanced at the time of test and the test word is new. For example, Jacoby and Whitehouse used briefly presented masked primes to manipulate processing fluency of test items during a recognition memory test. On one third of the trials, the prime matched the test item (match items) and on the remaining trials the prime was an unrelated word or a nonword (mismatch trials). The results showed that participants were more likely to call an item “old” on match trials than on mismatch trials. The effect is observed on both studied items (targets) and new items (distractors) and is not limited to perceptual priming; similar results are observed when perceptual processing is enhanced by manipulating perceptual clarity (Goldinger et al., 1999; Whittlesea, 1993; Whittlesea, Jacoby, & Girard, 1991). Furthermore, the illusion is not limited to manipulations of perceptual fluency; research by Whittlesea and colleagues (Whittlesea, 1993; Whittlesea & Williams, 2001) and Rajaram and Geraci (2000) indicates that manipulations of conceptual fluency (the ease of conceptual processing) can also influence recognition memory judgments.

Although there is substantial evidence in support of the hypothesis that processing fluency can influence memory judgments, it is important to note that this influence is not inevitable. Participants do not use perceptual fluency as a cue to recognition in situations in which the study and test phases are in different sensory modalities (Miller, Lloyd, & Westerman, 2008; Westerman, Lloyd, & Miller, 2002). For instance, when fluency was enhanced using priming procedures similar to Jacoby and Whitehouse (1989) participants attributed enhanced perceptual fluency to prior exposure on a visual test list preceded by a visual study list, but enhanced fluency was not attributed to prior exposure on a visual test list preceded by an auditory study list. Furthermore, Westerman, Miller, and Lloyd (2003) found that enhanced perceptual fluency of test items does not affect recognition memory judgments when the study and test phases of an experiment are in dramatically different fonts or different perceptual forms. Interestingly, Westerman and colleagues (Lloyd, Westerman, & Miller, 2003; Westerman et al., 2002, 2003) reported similar results from experiments that used “counterfeit” study lists as those that used actual study lists. Participants who were under the impression that they had viewed a visual subliminal study list (when, in actuality, they viewed only static) were more likely to interpret perceptual fluency as a cue for prior occurrence on a visual test than participants who were under the impression that they had heard an auditory subliminal study list and then took a visual study list. Similarly, participants who were given a counterfeit list that supposedly consisted of pictures did not use the fluency heuristic on a later recognition test of words (which were supposedly labels of the pictures presented in the study phase). However, when participants saw the identical counterfeit list, but were told that they were viewing words, they were more likely to respond positively to fluent items on the word recognition test. In combination, these results suggest that it is the instructions to the participant regarding the perceptual match of the study and test (rather than an actual perceptual match) that modulates the use of perceptual fluency as a cue to recognition. The interpretation of this finding that was offered by Westerman and colleagues is that participants take into account (either consciously or unconsciously) the degree to which fluency is a sign of past occurrence in different recognition situations. Perhaps because prior exposure to a stimulus results in less perceptual fluency when the first and second exposures are in different sensory or perceptual forms than when they are in the same form (i.e., the reduced perceptual priming found across

modalities [e.g., Roediger & Blaxton, 1987]), participants' recognition decisions are not as heavily influenced by the fluency of the test item when making a recognition decision in such situations.

Although the abovementioned results suggest that the use of the fluency heuristic in younger adults is sophisticated and appears to operate in a strategic manner (i.e., using fluency in situations in which it is most relevant to the recognition decision), it is not yet clear whether the interaction between study and test modality and the use of the fluency heuristic in recognition is the result of conscious or unconscious processes. A recent study by Miller, Lloyd, and Westerman (2008), showed that younger participants are very reluctant to use the fluency heuristic on a visual recognition test when the target had previously been presented aurally even when the experimental procedures were designed to make participants believe that perceptual fluency would be relevant to their recognition decisions. Although these results do not rule out a conscious process, it suggests that the processes that modulate the interaction between modality match and the role of perceptual fluency in recognition are not easily malleable by experimenter instructions.

The current study has two goals. The first goal was to examine whether older adults are more vulnerable to memory distortions created by experimental manipulations of processing fluency. The available evidence is mixed. For example, compared with younger adults, older adults are more likely to make repetition errors and judge repeated non-famous names as famous in a fame judgment task (Dywan & Jacoby, 1990; Jennings & Jacoby, 1993; Multhaup, 1995) and are more likely to make false alarms to lures repeated at test (Dodson & Schacter, 2002; Dywan, Segalowitz, & Webster, 1998; Jennings & Jacoby, 1997; Koriat, Ben-Zur, & Sheffer, 1988). In contrast to these findings, Thapar and Sniezek (2008) did not find age-related differences in the revelation effect. The revelation effect is the finding that studied and unstudied items that are preceded by a problem solving task (e.g., solving anagrams, math problems, reading rotated or inverted words, etc.) are more likely to be called "old" on a recognition memory test. Thapar and Sniezek observed a reliable revelation effect in older adults when participants solved word fragments (Experiment 1) or anagrams (Experiment 2) prior to making a recognition memory decision, but the magnitude of the effect was similar for younger and older adults. Jones and Jacoby (2005) observed a similar pattern of results in the feature-conjunction paradigm. In this paradigm, participants show increased false alarm rates to words such as *nightcap* and *heartache* after studying parent words *nighthawk*, *heartburn*, and *toothache*. Feature errors are false alarms to lures constructed by combining an old element with a new element (e.g., *nightcap*) and conjunction errors are false alarms to lures constructed by rearranging two old elements (e.g., *heartache*). Jones and Jacoby did not find age-related differences in false alarms rates to feature and conjunction lures when participants were uninformed of the lures (Experiment 1). Overall, the work by Thapar and Sniezek and Jones and Jacoby indicates that increased vulnerability to memory illusions is not necessarily a hallmark of aging.

The second goal of this study was to examine whether, in older participants, the use of the fluency heuristic in recognition memory judgments is attenuated in situations in which perceptual fluency is not as diagnostic of prior exposure (that is, when there is a change in modality between study and test). Particularly relevant to the present study is the work by Schacter and colleagues on age differences in the use of the distinctiveness heuristic to suppress false memories (Dodson & Schacter, 2002; Koutstaal, Schacter, Galluccio, & Stofer, 1999; Schacter, Israel, & Racine, 1999). For example, Schacter et al. found that younger and older adults were equally successful in suppressing false memories in the DRM paradigm after studying pictures as compared to words. Koutstaal et al. reported dramatic reductions in both younger and older adults' false recognition rates following instructions to use a more stringent decision criterion (for similar results in the false fame paradigm, see Multhaup, 1995). Dodson

and Schacter extended this work to false memories in the repetition lag paradigm. Participants studied pictures or words and then completed a recognition memory test in which the studied words or the labels corresponding to the pictures appeared once and new items appeared twice at either a lag of 24 or 48 items. Dodson and Schacter found that both younger and older adult participants made more false alarms to repeated new words in the word encoding condition than in the picture encoding condition. Replicating previous findings, older adults in the word encoding condition made more false alarms to repeated new words than younger adults in the word encoding condition. In contrast, older adults in the picture encoding condition had levels of false alarms similar to younger adults. In summary, although older adults had a higher rate of repetition errors in the word encoding condition, they were able to use the distinctiveness heuristic, a type of meta-memorial strategy, to suppress repetition errors in the picture encoding condition. To the extent that the fluency heuristic is also a type of meta-memorial strategy, we would predict age invariance in the processes that modulate the use of the fluency heuristic in recognition memory.

To summarize, previous research has shown that older adults are particularly vulnerable to memory distortions, but it is not clear whether this vulnerability extends to perceptual and conceptual fluency-based illusions in recognition memory. Likewise, it is unclear whether the use of the fluency heuristic in older adults will be sensitive to the match in sensory modality of the study and test phases, as is found with younger adults. In the present study, we examined the effect of enhanced perceptual fluency (Experiment 1) and enhanced conceptual fluency (Experiment 2) on recognition memory judgments when there was and was not a change in sensory modality between the study and test phases of an experiment.

Experiment 1

In this experiment, we adopted the masked repetition priming procedure popularized by Jacoby and Whitehouse (1989) to enhance the processing fluency of a portion of the items on a recognition test. Participants studied a list of words, presented either visually or aurally, and then were given a visual recognition test on which some of the test items were preceded by a brief repetition prime. In young adults, the priming manipulation typically creates an illusion of memory as long as the study and test phases are in the same modality. However, if modality is changed between study and test, the effect of the prime is attenuated (Westerman et al., 2002, 2003). The purpose of this experiment was to examine age differences in attribution and interpretation of enhanced perceptual fluency in recognition memory.

Methods

Participants—Sixty-eight younger adults and 60 older adults (age range 60-75; $M = 68.51$, $SD = 4.55$) participated in this experiment for pay or course credit. The younger adults were traditional-aged college students enrolled at SUNY Binghamton and Bryn Mawr College. The older subjects were healthy, active, community-dwelling individuals 60 to 85 years old living in the suburbs of Philadelphia recruited from advertisements placed in local newspapers. The older adults were carefully screened to exclude those with a history of head trauma, neuropsychological or psychiatric disorder, cardiac disease, or other serious chronic illness. All older adults had Mini-Mental State Examinations scores of 27 or more (Folstein, Folstein, & McHugh, 1975). All participants were native English speakers, had normal or corrected-to-normal vision and hearing, and were tested individually.

Materials and Design—The stimuli were 126 eight- and nine-letter words selected from the Kucera and Francis corpus (1967). The study list consisted of 66 words (6 primacy and recency buffer words, 30 target words, and 30 filler words) and the recognition memory test consisted of 60 words (30 targets and 30 lures). During the memory test, half of the target words and half of the lures were preceded by a prime that matched the test word and the

remaining words were preceded by a prime that was unrelated to the test word. The status of the test words (target or lure) and the prime type (matching or mismatching) were counterbalanced across subjects. Participants in the visual list condition received a different random order of words on the study list. Participants in the auditory list condition heard one of two different randomly ordered lists of words. All participants received a different random order of words on the recognition memory list. The design was a 2 (Age Group: young vs. old) $\times$ 2 (Study Modality: visual or aural) $\times$ 2 (Item Status: old vs. new) $\times$ 2 (Prime Type: matched vs. unmatched) mixed factorial design; Age Group and Study Modality were manipulated between-subjects and Item Status and Prime Type were manipulated within-subjects. The dependent variable was the proportion of “yes” (old) responses in each condition.

Procedure—Half of the younger and older adult participants were randomly assigned to either the auditory-list or the visual-list condition (34 younger and 30 older adults in each condition). The experiment consisted of a study phase and a test phase. All participants were instructed to learn the list of study words for an unspecified memory test. Participants in the visual study list condition saw the study list on a computer monitor. In that condition, each stimulus appeared on the screen in capital letters for 2 s, with a 1 s interval between items. The participants in the auditory study list condition heard a list of words over headphones. The list was spoken at a moderate pace in a male voice with a 1 s interval between each word. Immediately following the study phase, all participants were given a visual recognition memory test. Participants were told that half of the words on the recognition test had been presented during the study phase (old words) and half had not been presented (new words) and their task was to decide whether the test word had been previously presented. They were instructed to press the “y” key if they believed that the word had appeared on the study list and the “n” key if they believed that the word had not appeared on the study list. Each test word was immediately preceded by a prime. The prime was presented for 34 ms and was masked by a row of number signs that appeared for 250 ms before and after the word. For half of the trials, the prime was the same word as the test word (matching prime), for the remaining trials, the prime did not match the test word that followed it (mismatching prime). Participants were told that the flashing number signs were to alert them that a test word would be presented soon. After presentation of the masked prime, the screen was blank for 500 ms, and then the test word was presented. The recognition probe remained on the screen until the participant responded, after which the screen was blank for 4 s, followed by the next prime-recognition trial combination.

Results

A significance criterion of .05 was used to interpret the results of all statistical analyses. The results of Experiment 1 are summarized in Table 1 as a function of age group and experimental conditions. This table shows that both younger and older adult participants were more likely to call an item “old” on match trials than on mismatch trials; however the effect was limited to the visual study list condition. These conclusions were supported by the results of a 2 (Age Group: younger or older) $\times$ 2 (Study Modality: visual or auditory) $\times$ 2 (Item Status: old vs. new) $\times$ 2 (Prime Type: match vs. mismatch) mixed-factor ANOVA. Specifically, participants who saw the study list ($M = .50$, $SD = .15$) gave more “old” responses than participants who heard the study list ($M = .46$, $SD = .15$), $F(1, 124) = 4.37$, $p = .04$, $\eta^2_p = .04$. Participants gave more “old” responses to old words ($M = .69$, $SD = .15$) than to new words ($M = .27$, $SD = .12$), $F(1, 124) = 648.01$, $p < .001$, $\eta^2_p = .84$, and they gave more old responses to match-prime test words ($M = .50$, $SD = .12$) than to mismatch-prime test words ($M = .46$, $SD = .11$), $F(1, 124) = 16.24$, $p < .001$, $\eta^2_p = .12$. The main effects of Prime Type and Study Modality were qualified by a significant Prime Type by Study Modality interaction, $F(1, 124) = 5.09$, $p = .03$, $\eta^2_p = .04$. Participants who saw the study list gave more “old” responses to match-prime ($M = .54$, $SD = .12$) than to mismatch-prime ($M = .46$, $SD = .11$) test words, $t(63) = 4.85$, $p < .001$, whereas

participants who heard the study list gave a similar proportion of “old” responses to match ($M = .47$, $SD = .12$) and mismatch-prime ($M = .45$, $SD = .13$) test words ($t(63) = 1.20$, $p = .24$). Finally, although the main effect of Age was not significant, $F(1, 124) = 1.12$, $p = .28$, $\eta^2_p = .01$, there was a significant Age Group by Item Status interaction, $F(1, 124) = 3.92$, $p = .05$, $\eta^2_p = .03$. Younger adults had higher proportion of hit rates compared to older adults ($M_Y = .71$, $SD = .13$, $M_O = .66$, $SD = .17$; $t(126) = 1.98$, $p = .05$), but the two groups had similar proportion of false alarms ($M_Y = .27$, $SD = .12$, $M_O = .28$, $SD = .13$; $t(126) = -0.58$, $p = .56$). None of the remaining interactions reached significance (all p 's $> .25$). Among these null results, the most important was that the Age Group $\times$ Prime Type $\times$ Study Modality interaction, $F(1, 124) = 0.67$, $p = .42$, $\eta^2_p = .005$, was not significant. Thus, both age groups showed the same pattern: a reliable priming-induced illusion on recognition memory judgments when there is a match between study and test modality but not when there is a change.

Experiment 1 was designed to examine age differences in susceptibility to memory distortions created by experimental manipulations of processing fluency and to examine whether the attenuated use of the fluency heuristic in recognition memory judgments is found with older adults (as it is with younger adults) in situations in which the study and test phases are in different sensory modalities. The results can be summarized as follows: Older adults were vulnerable to recognition memory illusions resulting from experimental manipulations of perceptual fluency, but no more so than younger adults who were also susceptible to this type of memory illusion. Finally, the attenuated use of the fluency heuristic on a visual recognition test when targets were from an auditory study list was found for both younger and older adults. In summary, these results replicate and extend the findings reported by Westerman and colleagues and show that both younger and older adults are sensitive to the modality of the study and test phases of an experiment when attributing enhanced perceptual fluency to familiarity (Westerman et al., 2002).

Experiment 2

The results of Experiment 1 suggest that younger and older adults' recognition memory judgments are similarly affected by enhanced perceptual fluency. In Experiment 2, we examine age differences in attribution and interpretation of enhanced conceptual fluency. Previous research has shown that older adults are particularly vulnerable to associative memory illusions such as the DRM paradigm (e.g., Balota et al. 1999; Koutstaal & Schacter, 1997; Norman & Schacter, 1997). In this experiment we modified a paradigm originally used by Gellatly, Banton, and Woods (1995) to manipulate processing fluency. The manipulation involved presenting a series of context words and nonwords just prior to the recognition test word. For half of the test trials, one of the context stimuli matched the subsequent test word, and for the other half of the trials, none of the context stimuli matched the test word. Participants were given the task of making a lexical decision for each context word. The lexical decision task is assumed to involve the access of word-meaning (e.g., Chumbley & Balota, 1984), and thus is assumed to more heavily involve conceptually-based processing of context words compared to the perceptual priming technique used in Experiment 1. A recent study with younger adults as participants found that whereas perceptual match between study and test phases of an experiment was critical for participants to attribute *perceptual* fluency to prior occurrence, this is not the case when the fluency manipulation was more *conceptual* (Miller, Llyod, & Westerman, 2008). In two experiments, it was shown that when the fluency task involved the access of word meaning (by using the lexical decision task described above or by presenting the test words as the ending of predictive sentence stems), the sensory modality of the study and test phases did not modulate the effect of fluency on recognition responses. The implication of Miller et al.'s findings is that younger adults experience perceptual and conceptual fluency differently and that the decision-making biases operating on recognition memory judgments depend on the type of fluency that is experienced. The purpose of Experiment 2 was to examine

age differences in recognition memory illusions resulting from a more conceptually driven manipulation of processing fluency and to examine whether Miller et al.'s findings would extend to older adults.

Methods

Participants—Forty-six younger adults and 60 older adults (age range 60-80; $M = 70.25$, $SD = 5.84$) were recruited in the same manner as described for Experiment 1. The younger adults participated for course credit and older adults were paid \$15 for their participation.

Materials and Design—The materials were identical to those used in Experiment 1 with the exception of the priming phase that preceded each recognition test trial. In this experiment, the priming phase consisted of a series of five lexical decisions. When the lexical decision word matched the test word it occupied either the second or third position in the series of five trials. The other trials consisted of randomly placed words and nonwords. There were 300 lexical decision trials in total (five for each of the 60 test words); 30 of the words used in the lexical decision task were test words (15 were old words that appeared on the study list and 15 were new words); the other 120 words were from the same pool as the study and test words but had not been presented earlier in the experiment, and 150 stimuli were pronounceable nonwords that were constructed by the authors and were comparable in length to the words that were used in the task.

Procedure—Half of the younger and older adult participants were randomly assigned to either the auditory-list or the visual-list condition (23 younger and 30 older adults in each condition). The study phase procedures were identical to Experiment 1. On the recognition test, each test trial was preceded by a series of five stimuli. Each stimulus was either a word or a pronounceable nonword and participants made a word or nonword judgment aloud for each by saying “yes” (for word) or “no” (for nonwords). Responses were recorded with a tape recorder to assure compliance. Each lexical decision stimulus was presented for 1 s separated by a 500 ms delay. After the series of five lexical decision tasks was over, participants saw the test word and made a yes or no recognition judgment regarding its presence on the earlier study list. When explaining the procedures to the participants, the experimenters made an effort to ensure that participants understood that the yes/no recognition judgment referred to a test item's presence on the study list (not the short list of 5 words that they were exposed to during the lexical decision phase). Lastly, as with Experiment 1, participants were informed that half of the words on the recognition test had been presented during the study phase and half had not been presented.

Results

The results of Experiment 2 are summarized in Table 1. The table shows that attributions of processing fluency based on conceptual manipulations are insensitive to modality changes between study and test; younger and older adult participants were more likely to call an item “old” on match trials than on mismatch trials regardless of whether they had received a visual study list or an auditory study list condition. These conclusions were supported by the results of a 2 (Age Group: younger or older) $\times$ 2 (Study Modality: visual or auditory) $\times$ 2 (Item Status: old vs. new) $\times$ 2 (Prime Type: match vs. mismatch) mixed-factor ANOVA. Specifically, the ANOVA results revealed a significant main effect of Item Status with participants giving more “old” responses to old words ($M = .72$, $SD = .18$) than to new words ($M = .37$, $SD = .15$), $F(1, 102) = 368.69$, $p < .001$, $\eta^2_p = .78$, and Prime Type with more “old” responses to match-prime ($M = .61$, $SD = .15$) than to mismatch-prime test words ($M = .48$, $SD = .15$), $F(1, 102) = 100.53$, $p < .001$, $\eta^2_p = .50$. Two of the second-order interactions were also significant: Item Status and Prime Type, $F(1, 102) = 9.60$, $p = .003$, $\eta^2_p = .09$, and Prime Type and Study Modality, $F(1, 102) = 4.18$, $p = .04$, $\eta^2_p = .04$. These second-order interactions were qualified by a significant

four-way interaction among Age, Item Status, Prime Type, and Study Modality, $F(1, 102) = 4.54, p = .04, \eta^2_p = .04$. None of the remaining main effects or interactions reached significance (all p 's $> .10$).

The four-way interaction was further analyzed by conducting separate 2 (Study Modality) $\times$ 2 (Item Status) $\times$ 2 (Prime Type) mixed-factor ANOVAs on younger and older adults' memory performance. For the younger adults, this ANOVA revealed a significant main effect of Item Status ($F(1, 44) = 193.78, p < .001, \eta^2_p = .82$), Prime Type ($F(1, 44) = 28.36, p < .001, \eta^2_p = .39$), and a three-way interaction among Item Status, Prime Type, and Study Modality, ($F(1, 44) = 4.42, p = .04, \eta^2_p = .09$). The three-way interaction reflected the fact that the fluency manipulation affected targets and lures similarly in the auditory study list condition ($t(22) = 0.15, p = .88$) but affected targets more than lures in the visual study list condition ($t(22) = 3.12, p = .005$).

The comparable ANOVA for the older adults revealed a significant main effect of Item Status ($F(1, 58) = 1875.59, p < .001, \eta^2_p = .76$), Prime Type ($F(1, 58) = 84.84, p < .001, \eta^2_p = .59$), and significant two-way interactions between Prime Type and Study Modality ($F(1, 58) = 6.11, p = .02, \eta^2_p = .10$) and Item Status and Prime Type ($F(1, 58) = 6.73, p < .01, \eta^2_p = .10$). The three-way interaction among Item Status, Prime Type, and Study Modality was not significant ($F(1, 58) = 0.29, p = .59, \eta^2_p = .005$). Follow-up analyses revealed that the Prime Type and Study Modality interaction is due to the fact that although the fluency manipulation influenced both the auditory ($t(29) = 5.04, p < .001$) and the visual study list group ($t(29) = 7.86, p < .001$), the magnitude of the effect was larger for the visual study list group ($t(58) = 2.47, p = .016$). Finally, the Item Status and Prime Type interaction is due to the fact that although the fluency manipulation influenced both the lures ($t(59) = 8.47, p < .001$) and the targets ($t(59) = 5.77, p < .001$), the magnitude of the effect was larger for the lures than the targets ($t(59) = 2.60, p < .01$). Thus, the critical finding in this study is that both age groups interpreted enhanced conceptual fluency as a sign of prior occurrence, irrespective of study modality.

To summarize, Experiment 2 was designed to examine age differences in susceptibility to memory distortions resulting from manipulations of perceptual and conceptual fluency and to examine whether older adults would interpret enhanced fluency as a cue of prior occurrence when there is a change in perceptual match between the study and test phases of an experiment. Replicating the pattern observed in Experiment 1, we did not observe age differences in susceptibility to this type of memory illusion. However, in contrast to Experiment 1, younger and older adults reliably interpreted enhanced fluency as a cue of prior occurrence in both the auditory and the visual study list conditions.

General Discussion

The goal of this study was to investigate older adults' vulnerability to fluency-based memory illusions. The results from two experiments indicated that older adults interpreted enhanced processing fluency as a cue of prior occurrence. Moreover, older adults were not more vulnerable than younger adults to this type of memory illusion. Finally, whereas a perceptual match between study and test phases of an experiment was critical for younger and older adults to attribute perceptually-driven manipulations of processing fluency as a cue of prior occurrence (Experiment 1), this was not the case for more conceptually-driven manipulations of processing fluency (Experiment 2).

The principle contribution of the present study is the finding that older adults were not more vulnerable to memory illusions resulting from retrieval-based manipulations of processing fluency. These results are consistent with findings reported with the revelation effect and the memory conjunction paradigm (Thapar, 2009; Thapar & Snizek, 2008; Jones & Jacoby,

2005). For instance, Thapar and Snizek found that younger and older adults produced similar rates of false alarms to recognition memory probes that initially appeared in a distorted form and had to be solved (e.g., the anagram *ADCEHAEH* is solved to reveal the test probe *HEADACHE*) prior to making a recognition memory judgment. Subsequent work by Thapar (2009) extends these findings to revelation tasks where the revealed item (e.g., the anagram *ADCEHAEH* solved to reveal *HEADACHE*) is different from the recognition memory probe (e.g., *UMBRELLA*). Jones and Jacoby reported a similar finding in the memory conjunction paradigm with younger and older adults producing similar rates of false alarms to novel test probes (e.g., *heartache*) composed of component features of previously studied items (e.g., *heartburn* and *toothache*). Finally, our results are also consistent with those reported by Parks and Toth (2006) on the illusion of truth effect. The illusion of truth effect is the finding that repeated statements are rated as more credible than nonrepeated statements (e.g., Hasher, Goldstein, & Toppino, 1977). Previous studies have shown that repetition-based illusions of truth are even more compelling for older adults (Law, Hawkins, & Craik, 1998; Skurnik, Yoon, Park, & Schwarz, 2005). Parks and Toth manipulated processing fluency to induce the illusion of truth effect and found that younger and older adults were equally susceptible to fluency-based illusions of truth.

On the other hand, our results appear to conflict, at first, with findings reported with the fame judgment (Dywan & Jacoby, 1990; Jennings & Jacoby, 1993; Multhaup, 1995) and the repetition lag paradigm (Dodson & Schacter, 2002; Dywan, Segalowitz, & Webster, 1998; Jennings & Jacoby, 1997; Koriat, Ben-Zur, & Sheffer, 1988). For example, Dywan and Jacoby presented younger and older adults with a list of nonfamous names, followed by a fame judgment task comprised of famous names, new nonfamous names, and previously presented nonfamous names. Dywan and Jacoby found that older adults were more likely to judge repeated non-famous names as famous. Jennings and Jacoby (1997) reported a similar pattern with the repetition lag paradigm with older adults more likely to falsely endorse new items repeated at test as “old. These results are typically explained according to dual-process models of recognition memory that posit that the ability to remember is supported by recollection and familiarity (see Yonelinas, 2002, for a review of the evidence supporting this distinction) and that these processes are differentially affected in normal aging (e.g., Light, Prull, LaVoie, & Healy, 2000). Specifically, Jacoby and colleagues argue that memory errors in the fame judgment and the repetition lag paradigm reflect the influence of familiarity in the absence of recollection and that younger adults are able to use recollection to avoid making false repetition errors.

We offer a tentative explanation in an effort to reconcile these disparate findings. Specifically, we posit that younger and older adults were similarly vulnerable to our fluency-based memory illusions because younger adults were not able to use recollection to oppose or discount priming-based familiarity in Experiment 1, as the primes were presented too quickly to be seen. In Experiment 2, although the context words were clearly visible to participants, the connection between the context words and the test words was camouflaged by the fast-paced lexical decision tasks that preceded each test word. Gellatly et al. (1995) used procedures similar to those used in Experiment 2 to test young adults and found that unless the connection between the fluency task and the recognition task was very salient (by having participants monitor both tasks and look for repetitions), an illusion of recognition memory was found when test words matched one of the context words. It should also be noted that in our experiments, unlike in the false fame studies (e.g., Dywan & Jacoby, 1990), recollection of the prime is not diagnostic of the target or lure status of the test items. In the false-fame paradigm, participants are initially presented with a list of names and are (correctly) informed that the names are not famous. Therefore, the ability to recollect that a name was presented in an earlier phase of the experiment would be diagnostic of that names' nonfamous status. Because both targets and lures were primed in our study, there was not the same diagnostic relationship between the primes and

the test items. In our experiments, rejecting a test word because it was preceded by a matching primed word would result in a miss if the word was a target. Therefore, it seems unlikely that the younger participants used the same type of conscious recollection strategy that is found in false-fame studies to interpret the fluency of the test items in the current study. This may have contributed to our younger adults' failure to use recollection to oppose or discount priming in the current tasks.

The proposed explanation is supported by findings such as those reported by Jacoby (1999) who found that younger and older adults were equally vulnerable to memory errors in the repetition-lag paradigm when younger adults were not able to use recollection to oppose familiarity (e.g., they were forced to respond quickly or to perform a secondary task). In a similar vein, Multhap (1995) failed to find age-related differences in the false fame paradigm when older adults were encouraged to use recollection at test by having to indicate whether a test name was famous, one that they had read before, or new.

The procedures used in the current study resemble those used by Jacoby and colleagues to demonstrate dramatic levels of false remembering on a cued-recall task (Jacoby, Bishara, Hessels, & Toth, 2005). In their study, a 500 ms prime presented prior to a cue on a cued-recall task greatly increased false recall (of the prime) when that prime was a related non-target. The effects of the primes were more dramatic for older adults than younger adults, and older adults were also more likely than younger adults to claim that their false memories were clear memories, rather than guesses. Jacoby and colleagues theorized that the older adults were more likely to experience an attentional "capture" as a result of the prime. When the prime was a non-target, this "capture" made it difficult to bring the target to mind, and, as a result, participants falsely recalled the prime instead of the target. We did not find that older adults were more likely than younger adults to be "captured" by the primes in our study. However, based on the Jacoby et al. results, we would not expect to given our use of a recognition test, as they found little evidence of capture on a recognition test. In fact, it was the attenuation of false memory in recognition memory (compared to cued-recall) that led the authors to favor an account based on attentional capture rather than a source confusion explanation. In other words, although we did not find that older adults were more susceptible to attentional capture, we suspect that this was because our experiments measured recognition memory, rather than cued-recall.

Finally, in the present study, older adults, like younger adults, were less likely to attribute enhanced perceptual fluency to prior exposure when the study and test phases were presented in different modalities (for similar results with the distinctiveness heuristic, see Dodson & Schacter, 2002; Koutstaal, Schacter, Galluccio, & Stofer, 1999; Schacter, Israel, & Racine, 1999). In contrast, when the fluency manipulation accessed both perceptual and conceptual fluency, older adults attributed enhanced processing fluency to prior exposure irrespective of the modality match between the study and test phases. These results are concordant with those reported by Westerman et al. (2002) and Miller et al. (2008). Westerman et al. used briefly presented masked primes to manipulate processing fluency of test items during a recognition memory test and found that younger adults would attribute enhanced perceptual fluency to prior exposure when the study and test phases were presented in the same modality but not when they were in different modalities. In contrast, Miller et al. found that when processing fluency was enhanced by manipulations that involved access to the word meaning (i.e., a lexical decision task or by presenting the test words as the ending of predictive sentence stems), younger adults would attribute enhanced conceptual fluency to prior exposure regardless of whether the study and test phases were presented in the same or different modalities. Taken together, these results indicate that participants in both age groups are sensitive to the match between perceptual features at study and test when making attributions regarding enhanced perceptual fluency but not when making attributions regarding enhanced conceptual fluency.

The finding that the effect of a modality change on fluency-based recognition responses depended on the manner in which fluency was manipulated is in line with other findings that also suggest that processing fluency is not a generic experience. For instance, a recent study showed that there are different patterns of electrophysiological activity associated with perceptual fluency and semantic familiarity. Using famous and nonfamous faces as stimuli, Nessler, Mecklinger, and Penney (2005) found that semantic familiarity was characterized by early onset (200-300ms) broadly distributed activity followed by frontally distributed activity (at 300-400ms), whereas perceptual fluency was associated with later (300-400 ms) activity that was posteriorly focused. Nessler et al.'s results support the notion that perceptual and conceptual fluency are experienced differently by participants. The present results are also consistent with findings from the implicit memory literature that show that a change in perceptual features between the study and test phases (e.g., modality, font, pictures to words) affects priming in perceptual implicit tests more than conceptual implicit tests (e.g., Blaxton, 1989).

The results from the two experiments reported here replicate and extend these findings to older adults. The implication of these findings is that both younger and older adults experience perceptual and conceptual fluency differently and that the processes that modulate the use of the fluency heuristic in response to changes in sensory modality are similar in younger and older adults. As noted in the introduction, it is not yet clear whether the modulation of the fluency heuristic is the result of a conscious strategy or unconscious processes, however a recent experiment showed that the attenuation of fluency effects after a change in perceptual form (from pictures to words) remained even under speeded test conditions (Gallo, Perlmutter, Moore, & Schacter, 2008). The fact that speeded responding did not alter the effect suggests that participants are not adopting a conscious item by item discounting strategy even when responses are self-paced.

In conclusion, a considerable body of research has investigated age related changes in vulnerability to memory illusions and has demonstrated that older adults are more vulnerable to memory intrusions and distortions. In contrast, our data indicate that older adults are not more vulnerable to memory illusions resulting from retrieval-based manipulations of processing fluency. The present findings, in conjunction with those reported by Jones and Jacoby (2005), Thapar (2009), and Thapar and Snizek (2008) suggest that while aging may be associated with increased vulnerability to certain encoding- and retrieval-based memory illusions, this increased vulnerability is not necessarily a hallmark of aging.

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Table 1
Mean proportions of “old” responses (SDs in parentheses) as a function of age, priming condition, item status, and test format for Experiments 1 and 2

	Visual Study Modality			Auditory Study Modality		
	Match	Mismatch	Priming Effect	Match	Mismatch	Priming Effect
Experiment 1:						
Young						
Targets	.77 (.13)	.71 (.15)	.06	.69 (.13)	.68 (.19)	.01
Lures	.34 (.18)	.21 (.11)	.13	.28 (.14)	.24 (.14)	.04
Elderly						
Targets	.69 (.14)	.64 (.17)	.05	.66 (.20)	.66 (.23)	.00
Lures	.34 (.15)	.29 (.16)	.05	.26 (.15)	.23 (.13)	.03
Experiment 2:						
Young						
Targets	.76 (.18)	.71 (.18)	.05	.75 (.14)	.65 (.16)	.10
Lures	.49 (.16)	.30 (.16)	.19	.38 (.19)	.29 (.20)	.09
Elderly						
Targets	.78 (.14)	.62 (.18)	.16	.76 (.19)	.69 (.21)	.07
Lures	.50 (.21)	.29 (.18)	.21	.42 (.24)	.27 (.24)	.15